

RCRA Facility Investigation – Remedial Investigation/
Corrective Measures Study – Feasibility Study Report
for the Rocky Flats Environmental Technology Site

Section 11.0
Detailed Analysis of Alternatives

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11.0 DETAILED ANALYSIS OF ALTERNATIVES

11.1 Introduction

This section presents an evaluation of alternatives for final remedial actions to be implemented to ensure that the residual contamination at the Rocky Flats Environmental Technology Site (RFETS or Site) does not present an unacceptable risk to human health or the environment. In accordance with the Rocky Flats Cleanup Agreement (RFCA) paragraph 83, after completion of all planned RFCA accelerated actions, the Colorado Department of Public Health and Environment (CDPHE) and the U.S. Environmental Protection Agency (EPA) will evaluate site conditions and render a final Corrective Action Decision (CAD) and Record of Decision (ROD) for each Operable Unit (OU).

For RFETS, based on several previous OU reconfigurations and approved CAD/RODs to date, the final remedial decision will address the Buffer Zone (BZ) OU and the Industrial Area (IA) OU. A final reconfiguration of these OUs based on the results of the Remedial Investigation (RI) has been proposed (see Section 9.6) to consolidate all areas of the site that may require final remedial actions into the final Central OU. The remaining portions of the site are unimpacted by site activities from a hazardous waste or constituent perspective and are acceptable for all uses from a radiological perspective. Consequently, these remaining portions of the site have been consolidated into the final Peripheral OU and a Feasibility Study (FS) is not required. The RFCA Parties will propose a No Action CAD/ROD for the Peripheral OU based on the results of the RI.

Four Remedial action objectives (RAOs) (groundwater RAO 2, groundwater RAO 3, soil RAO 1, and soil RAO 3) are not met in the Central OU. Two RAOs (surface water RAO and soil RAO 2) are met under current site conditions; consequently, institutional controls are needed to ensure that these RAOs will continue to be met. Most applicable or relevant and appropriate requirements (ARARs) are met in the Central OU as long as the land surface is not disturbed; consequently, institutional controls are needed to ensure that some ARARs will continue to be met.

Because the Comprehensive Risk Assessment (CRA) does not evaluate an unrestricted scenario, but instead evaluated potential risk to the anticipated future user (wildlife refuge worker [WRW] and wildlife refuge visitor [WRV]), the assumptions used in the CRA human health calculations, including the assumptions used in calculating WRW preliminary remediation goals (PRGs), need to be embodied in an institutional control.

Section 11.2 summarizes the specific areas of groundwater, surface water, and soil within the Central OU that do not meet all of the RAOs or that need an institutional control to ensure that the RAO will continue to be met. With the completion of the accelerated actions, the experience and knowledge gained during those actions, and from evaluation of alternatives in the preparation of accelerated action decision documents, the number of available options and alternatives to address residual contamination are limited and well understood. Consequently, no formal screening of alternatives prior to the selection of

alternatives that are evaluated in detail in this section is deemed necessary. Three alternatives for the Central OU are developed and evaluated in detail in accordance with the nine Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) evaluation criteria. First, the alternatives are analyzed individually against the criteria in Section 11.3; a comparative analysis of all the alternatives against the criteria is then presented in Section 11.4.

The following actions have been implemented in accordance with approved RFCA decision documents. The approved actions include monitoring requirements that will continue and will not be reevaluated in the detailed analysis of alternatives.

- Post-closure care and monitoring of the Present Landfill and continued operation and maintenance (O&M) of the Present Landfill seep treatment system;
- Post-closure care and monitoring of the Original Landfill; and
- O&M of three groundwater treatment systems and performance monitoring (East Trenches Plume Treatment System [ETPTS], Mound Site Plume Treatment System [MSPTS], and Solar Ponds Plume Treatment System [SPPTS]).

The Present Landfill was closed under the Resource Conservation and Recovery Act (RCRA)/Colorado Hazardous Waste Act (CHWA); the Original Landfill was closed under CERCLA using RCRA closure ARARs. Each of the landfills has a Closure Plan approved by CDPHE and EPA. A system to treat the Present Landfill seep was installed. A system to monitor groundwater upgradient and downgradient of both landfills is in place.

The other actions involve groundwater remediation. Results of the RI indicate that continued operation of these three groundwater systems serves to protect surface water quality over short- and intermediate-term periods by removing contaminant loading to surface water. This protection also serves to meet long-term goals for returning groundwater to its beneficial use of surface water protection.

11.2 Specific Media to Be Addressed in the Detailed Analysis of Alternatives

Based on the results of the RI, four RAOs (groundwater RAO 2, groundwater RAO 3, soil RAO 1, and soil RAO 3) are not met in the Central OU and two RAOs (surface water RAO and soil RAO 2) are met under current site conditions. Consequently, institutional controls are needed to ensure that the RAOs will continue to be met. This section identifies the specific areas within the Central OU that need to be evaluated in the detailed analysis of alternatives.

11.2.1 Groundwater

To recall, groundwater RAO 2 (Section 10.0) is:

Restore contaminated groundwater that discharges directly to surface water as baseflow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable timeframe. This is measured at groundwater Sentinel wells. Prevent significant risk of adverse ecological effects.

Results of the RI indicate that this RAO is not met at all Sentinel wells; however, at this time no other additional actions for these areas can reasonably be taken.

To recall, groundwater RAO 3 (Section 10.0) is:

Prevent domestic and irrigation use of groundwater contaminated at levels above maximum contaminant levels (MCLs).

A review of the RFETS data comparing groundwater results to MCLs indicates that there are some sampling locations within the Central OU where groundwater contamination exceeds MCLs. The groundwater monitoring locations where composite MCLs were exceeded in the Central OU are shown on Figure 11.1.

Based on this RAO, the detailed analysis of alternatives for the Central OU will evaluate alternatives that will prevent domestic and irrigation use of groundwater contaminated at levels above MCLs.

11.2.2 Surface Water

To recall, the surface water RAO (Section 10.0) is:

Meet surface water quality standards, which are the Colorado Water Quality Control Commission (CWQCC) surface water standards.

Results of the RI indicate that this RAO is met at all surface water Points of Compliance (POCs). However, surface water sample results do not always meet CWQCC surface water quality standards for some analytes at some on-site monitoring locations upstream of the terminal ponds.

The Ecological Risk Assessment (ERA) did not identify surface water site conditions due to residual contamination as representing a significant risk of adverse ecological effects to receptors from exposure to site-related contamination. However, additional surface water monitoring is needed to address uncertainties identified in the ERA.

Based on this RAO, the detailed analysis of alternatives for the Central OU will evaluate alternatives to prevent use of surface water upstream of the terminal ponds and add additional surface water monitoring to address uncertainties identified in the ERA.

11.2.3 Soil

To recall, soil RAO 1 (Section 10.0) is:

Prevent migration of contaminants to groundwater that would result in exceedances of groundwater RAOs.

Results of the RI indicate that this RAO is not met at all Sentinel wells; however, at this time no other additional actions for these areas can reasonably be taken.

To recall, soil RAO 2 (Section 10.0) is:

Prevent migration of contaminants that would result in exceedances of surface water RAOs.

Results of the RI indicate that this RAO is met provided residual soil contamination is not disturbed. If residual soil contamination is disturbed, the residual contamination could migrate to surface water via erosion which could result in some surface water sample results above surface water standards at some surface water monitoring locations.

Based on this RAO, the detailed analysis of alternatives for the Central OU will evaluate alternatives to prevent disturbance of soil.

To recall, soil RAO 3 (Section 10.0) is:

Prevent exposure resulting in unacceptable risk to a WRW. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives where ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at the site or multiple pathways of exposure (40 Code of Federal Regulations [CFR] 300.430 [e][2][i][A][2]). Prevent significant risk of adverse ecological effects.¹

Soil RAO 3 is not met for human health, but it is met for the environment. Because the CRA does not evaluate an unrestricted scenario, but instead evaluates potential risk to the anticipated future user (WRW and WRV), the assumptions used in the CRA human health calculations, including the assumptions used in calculating WRW PRGs, need to be embodied in an institutional control. The detailed analysis of alternatives will evaluate alternatives that include the underlying assumptions used in the CRA human health calculations as an institutional control.²

Additionally, the CRA included an analysis comparing subsurface soil and groundwater data to indoor air volatilization PRGs. The subsurface soil sampling locations where volatilization PRGs were exceeded are shown on Figure 11.2. The groundwater sampling locations where volatilization PRGs were exceeded are shown on Figure 11.3. The sampling locations with groundwater contamination above the indoor air volatilization PRGs are included in the discussion of the soil RAO because the results of the CRA analysis indicate the possibility of an unacceptable risk to the WRW if WRWs were to

¹ Under CERCLA, it must be shown that risks for expected land uses at the site fall within the acceptable range of 1×10^{-6} to 1×10^{-4} cancer risks and below a hazard index (HI) of 1 for noncarcinogenic effects.

² These institutional controls will also address the CHWA Individual Hazardous Substance Site (IHSS)-by-IHSS approach to risk management.

spend 50 percent or more of their work day in an indoor office building constructed over the area.

Results of the CRA indicate potential risk to a WRW is estimated to be 2×10^{-6} for exposure to plutonium-239/240 in surface soil in the Wind Blown Area Exposure Unit (EU) (WBEU). A review of the RFETS data indicates that residual plutonium-239/240 surface soil contamination in some locations exceeds the WRW PRG (based on 1×10^{-6} target risk) concentration of 9.8 picocuries per gram (pCi/g). This area of residual surface soil contamination is shown on Figure 11.4.

The ERA did not identify ecological or sediment site conditions due to residual contamination as representing a significant risk of adverse ecological effects to receptors from exposure to site-related contamination. However, additional ecological and sediment monitoring is needed to address uncertainties identified in the ERA.

Based on this RAO, the detailed analysis of alternatives will evaluate alternatives that include the underlying assumptions used in the CRA human health calculation as an institutional control; prevent buildings from being constructed over sampling locations in the Central OU where the indoor air volatilization PRGs are exceeded, as shown on Figure 11.2 and Figure 11.3; add additional ecological and sediment monitoring to address uncertainties identified in the ERA; and reduce exposure to surface soil residual plutonium-239/240 contamination above 9.8 pCi/g in the area shown on Figure 11.4.

11.3 Detailed Analysis of Alternatives

A detailed analysis of three alternatives will be evaluated against the nine CERCLA criteria (40 CFR 300.430[e][9]). The nine evaluation criteria are:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability;
- Cost;
- State acceptance; and
- Community acceptance.

The evaluation criteria are divided into three groups based on the function of the criteria for remedy selection. The first group is the threshold criteria related to the statutory requirements that each alternative must satisfy in order to be eligible for remedy selection. These include:

- Overall protection of human health and the environment; and
- Compliance with ARARs.

The second group is the primary balancing criteria that are the technical criteria upon which the detailed analysis is based. These include:

- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

The third group is the modifying criteria, which includes:

- State acceptance; and
- Community acceptance.

State and community acceptance criteria will be addressed in the CAD/ROD after comments on the Proposed Plan have been received.

11.3.1 Alternative Definition

This section defines the three alternatives developed for the Central OU. Regardless of which alternative is selected for the final remedy, U.S. Department of Energy (DOE) will construct, for land management purposes, a barbed wire fence. It is anticipated that DOE and the U.S. Fish and Wildlife Service (USFWS) will agree that the Central OU boundary equates to the DOE-retained lands. This fence is not part of the final remedy.

11.3.1.1 Alternative 1: No Further Action With Monitoring

Alternative 1, No Further Action With Monitoring, maintains and monitors the completed actions conducted at the Present and Original Landfills and the three groundwater treatment systems. Specific monitoring and O&M requirements for these five actions will continue. Alternative 1 also includes additional environmental monitoring for surface water and groundwater as described in the Integrated Monitoring Plan (IMP) Fiscal Year (FY) 2005, Summary and Background Document, Revision 1 (K-H 2005). Alternative 1 will include maintenance and monitoring requirements as described below.

1. Present Landfill Cover System and Landfill Seep Treatment System, in accordance with the approved Monitoring and Maintenance Plan, which currently includes the following:
 - Inspection of the cover and runoff and runoff controls with maintenance as identified in the inspections;
 - RCRA groundwater monitoring by analyzing three upgradient and three downgradient wells for metals and volatile organic compounds (VOCs) with a statistical evaluation of the data consistent with groundwater monitoring ARARs;
 - Inspection of the seep treatment system with maintenance as identified in the inspections;
 - Monitoring of the seep treatment system by sampling and analyzing the influent and effluent of the seep treatment system for metals, VOCs, semivolatile organic compounds (SVOCs), and nitrates and conducting a statistical evaluation of the data compared to the surface water standards;
 - Inspection of the East Landfill Pond dam and outlet structures with maintenance as identified in the inspections;
 - Inspections, maintenance actions, and monitoring results that identify any adverse change in conditions (reported to the regulatory agencies in a timely manner, otherwise results reported annually to the regulatory agencies); and
 - Institutional controls as required by the Present Landfill RFCA decision document.
2. Original Landfill Cover System, in accordance with the approved Monitoring and Maintenance Plan, which currently includes the following:
 - Inspection of the cover and runoff and runoff controls and the toe buttress with maintenance as identified in the inspections;
 - RCRA groundwater monitoring by analyzing one upgradient and three downgradient wells for metals (including uranium), SVOCs, VOCs, and pesticides with a statistical evaluation of the data and a comparison of the downgradient groundwater quality with surface water standards;
 - Monitoring of surface water quality in Woman Creek by surface water sampling upstream and downstream of the Original Landfill with a statistical evaluation of the data compared to surface water standards; and
 - Inspections, maintenance actions, and monitoring results that identify any adverse change in conditions (reported to the regulatory agencies in a timely manner, otherwise results reported annually to the regulatory agencies).

3. Three Existing Groundwater Treatment Systems (MSPTS, ETPTS, and SPPTS), which include the following:
 - Inspection of each system with maintenance as identified in the inspections;
 - Monitoring of upgradient and downgradient groundwater with a statistical evaluation of the data to determine the operating performance of the treatment system;
 - Periodic replacement of treatment system media as required based on inspection and monitoring results; and
 - Inspections, maintenance actions, and monitoring results that identify any adverse change in conditions (reported to the regulatory agencies in a timely manner, otherwise results reported annually to the regulatory agencies).
4. The following RFETS Environmental Monitoring (as defined in the FY2005 IMP):
 - Surface water monitoring; and
 - Groundwater monitoring.
5. Additional surface water, sediment, and ecological monitoring based on uncertainties identified in the ERA.

The results of the IMP monitoring will be reported quarterly to the regulatory agencies. Any adverse change in conditions will be reported to the regulatory agencies in a timely manner.

The environmental monitoring required at the Present Landfill, Original Landfill, and the three groundwater treatment systems is also included in the FY2005 IMP.

11.3.1.2 Alternative 2: Institutional and Physical Controls

Alternative 2, Institutional and Physical Controls, adds the implementation of institutional and physical controls to Alternative 1. Institutional controls include legally enforceable and administrative land use restrictions and physical controls including signage or other physical features to control access and activity within the Central OU. Land use restrictions are limitations or prohibitions on specific activities within designated areas of the Central OU to ensure that the conditions remain protective for the WRW and WRV. Physical controls are items such as signage monuments along the perimeter of the Central OU to notify the WRW and WRV that they are at the boundary of the Refuge maintained by USFWS. DOE will retain jurisdiction over the engineered structures and monitoring systems associated with the completed actions. Institutional controls for the Central OU are described below.

1. The construction and use of buildings that will be occupied on a permanent or temporary basis (such as for residences or offices) is prohibited. The construction and use of storage sheds or other, nonoccupied structures is permitted, consistent with the restrictions contained in Steps 2 and 3 below, and provided such use does not impair any aspect of the response action at Rocky Flats.
2. Excavation, drilling, and other intrusive activities below a depth of 3 feet (ft) are prohibited, except for remedy-related purposes.
3. No grading, excavation, digging, tilling, or other disturbance of any kind of surface soils is permitted, except in accordance with an erosion control plan approved by CDPHE or EPA. Any such soil disturbance shall restore the soil surface to pre-existing grade.
4. Surface water above the terminal ponds may not be used for drinking water or agricultural purposes.
5. The construction or operation of groundwater wells is prohibited, except for remedy-related purposes.
6. Digging, drilling, tilling, grading, excavation, construction of any sort (including construction of any structures, paths, trails or roads), and vehicular traffic are prohibited on the covers of the Present Landfill and the Original Landfill, except for authorized response actions.
7. Activities that may damage or impair the proper functioning of any engineered component of the response action, including but not limited to any treatment system, monitoring well, landfill cap, or surveyed benchmark, are prohibited.

Physical controls will consist of signage installed along the perimeter of the Central OU to notify the WRW and WRV that they are at the boundary of the refuge maintained by USFWS.

Institutional and physical controls will be inspected every 3 months. If evidence of activities that violate the restrictions or damage of the physical controls is found, a plan will be developed to correct the condition and the correction will be implemented. Inspections and corrective actions will be documented in an annual report to the regulatory agencies.

11.3.1.3 Alternative 3: Targeted Surface Soil Removal

Alternative 3, Targeted Surface Soil Removal, will remove the top 6 inches of soil in areas of residual surface soil contamination that have activities above the plutonium-239/240 WRW PRG (based on 1×10^{-6} target risk) concentration of 9.8 pCi/g, as shown on Figure 11.4. This figure shows that surface soil over an area of approximately 368 acres would be removed. Note that this alternative may not completely remove all plutonium contamination within the 368 acres, but the residual risk based on the EU is

expected to be well below 1×10^{-6} if Alternative 3 is implemented. Previous excavation actions of a similar nature resulted in successful removal of contamination, as verified through post-accelerated action confirmation sampling based on a 90-percent confidence level.

This alternative also includes the implementation of Alternative 2.

The scope of this alternative would be to excavate the contaminated soil in a defined area to a depth of approximately 6 inches. The removed soil would be placed in shipping containers and then shipped for disposal at a permitted low-level radioactive waste (LLW) disposal facility. Confirmation samples would be collected to verify that the contaminated soil was removed to below 9.8 pCi/g. The excavated area will not be backfilled, but graded as necessary to match existing surrounding grades. The area would then be seeded for revegetation and mulched/matted for erosion control.

Temporary access roads, staging areas, and other infrastructure to conduct the removal would be built to conduct the work. Temporary construction facilities such as work trailers, equipment parking and fueling areas, and portable electrical power generators would be used during the construction period.

With the excavation of 6 inches of soil within this area, the volume of soil to be removed and shipped to the permitted disposal facility is approximately 10,425,000 cubic feet (ft³). The duration of this removal operation is estimated at 3 years.

11.3.2 Detailed Analysis of Alternatives

This detailed analysis of the alternatives assembles and develops the rationale to understand the various alternatives. Each alternative is evaluated against the nine evaluation criteria as further described below.

1. Overall Protection of Human Health and the Environment – The analysis of this threshold criterion describes how the alternative achieves and maintains protection of human health and the environment.
2. Compliance With ARARs – The analysis of this threshold criterion determines how the alternative meets the federal and state ARARs that have been identified for use in the evaluation of the alternatives and the selection of the final remedy at RFETS.
3. Long-Term Effectiveness and Permanence – This analysis considers the magnitude of residual contamination and/or risk after the alternative has been implemented and the adequacy, suitability, and reliability of the alternative to control/manage the residual contamination and risk.
4. Reduction of Toxicity, Mobility, or Volume Through Treatment – This analysis considers the treatment of residual contamination to reduce the contaminant toxicity, mobility, or volume. The analysis will describe the treatment process, degree of

treatment, degree to which the treatment is irreversible, and volume reduction achieved through treatment.

5. Short-Term Effectiveness – This analysis addresses the protection of the community and workers while implementing the alternative, environmental impacts while implementing the alternative, and time required achieving the RAOs.
6. Implementability – This analysis considers the ability to build and operate the alternative, reliability of the alternative, ability to monitor the effectiveness of the alternative, administrative feasibility of the alternative, and availability of resources to implement the alternative.
7. Cost – This criterion presents order-of-magnitude capital and O&M costs of the alternative. The O&M cost estimates will include the anticipated O&M costs along with administrative costs, replacement costs, and the cost of periodic reviews. A present worth analysis is also included for a period of 30 years with a discount rate of 5 percent (OMB 2005).
8. State Acceptance – This analysis evaluates the technical and administrative issues and concerns the state regulatory agency may have on the alternative. A discussion of this criterion will be provided in the CAD/ROD.
9. Community Acceptance – This analysis evaluates the technical and administrative issues and concerns that the community may have on the alternative. A discussion of this criterion will be provided in the CAD/ROD.

Table 11.1 summarizes the detailed analysis for each alternative.

11.3.3 Alternative 1: No Further Action With Monitoring

11.3.3.1 Overall Protection of Human Health and the Environment

Alternative 1 is protective of human health and the environment in the current site land configuration because no unacceptable risks from residual contamination exist after the completion of all planned RFCA accelerated actions. Specific issues are discussed below.

1. The CRA shows that the incremental risk to the WRW is at or below 1×10^{-6} or a hazard index (HI) of 1 for soil and sediment with residual contamination above background, except in the WBEU where the calculated risk to a WRW is 2×10^{-6} and to a WRV is 1×10^{-6} for plutonium-239/240. Under CERCLA, the WBEU is still considered protective of human health because the risk falls within the acceptable range of 1×10^{-6} to 1×10^{-4} cancer risks and an HI of 1 for noncarcinogenic effects.
2. The CRA predicts that there is no significant ecological risk from the residual contamination within all media for all of the ecological receptors evaluated in the ERA.

3. CRA results for the No Name Gulch Drainage EU (NNEU), including the Present Landfill without the implementation of the accelerated action, indicate that residual contamination exhibits an incremental risk to the WRW that is less than 1×10^{-6} . In addition, the installed multilayered geosynthetic cover and additional buttressing at the east face of the Present Landfill provide additional protection. The seep treatment system lowers the concentration of VOCs in the landfill seep to meet surface water quality standards with passive treatment.
4. CRA results for the Upper Woman Drainage EU (UWOEU), including the Original Landfill without the implementation of the accelerated action, indicate that residual contamination exhibits an incremental risk to the WRW that is less than 1×10^{-6} . In addition, the accelerated action provides for additional structural stability with a soil buttress and prevents direct contact with the landfill wastes and debris via placement of a soil cover.
5. Groundwater actions are operating as designed to remove contamination in captured groundwater to meet appropriate surface water quality standards at surface water POCs. Actions to address threats to surface water quality have included source removal and groundwater collection and treatment. The groundwater treatment systems will continue to operate and be monitored to protect surface water quality.
6. Monitoring of the RFETS groundwater, surface water, sediment, and ecology will provide the environmental data to verify that the site continues to be protective of human health and the environment. This monitoring will also include environmental monitoring at the Present and Original Landfills and performance monitoring of the three groundwater treatment systems.

Alternative 1 may not be protective to human health if the current site land configuration were to change. Specific concerns are described below.

1. Because the CRA does not evaluate an unrestricted scenario, but instead evaluates potential risk to the anticipated future user (WRW and WRV), the assumptions used in the CRA human health calculations, including the assumptions used in calculating WRW PRGs, need to be embodied in an institutional control. The detailed analysis of alternatives will evaluate alternatives that include the underlying assumptions used in the CRA human health calculations as an institutional control.
2. Residual soil contamination exists in the Central OU. If residual soil contamination is disturbed, the residual contamination could migrate to surface water via erosion which could result in some surface water sample results above surface water standards at some surface water monitoring locations. Alternative 1 does not prevent the disturbance of soil.
3. Subsurface soil and groundwater contamination exists above the indoor air volatilization PRGs. Alternative 1 does not actively prevent the possibility of an unacceptable risk of exposure to the WRW if a building were constructed over the

area contaminated above the indoor air volatilization PRGs, and the building was routinely occupied.

4. Groundwater contamination exists in the Central OU above MCLs. Alternative 1 does not actively prevent the use of this groundwater for drinking water or irrigation purposes.
5. Surface water quality standards are met at the surface water POCs, but surface water sample results do not always meet Colorado surface water standards for some analytes at some on-site surface water monitoring locations upstream of the terminal ponds. Alternative 1 does not actively prevent the use of this surface water.
6. The Present Landfill RFCA decision document requires institutional controls to be put in place at the time the post-closure period begins. However, institutional controls for the Original Landfill are not in place.
7. There are no prohibitions on the engineered aspects of the remedy.

11.3.3.2 Compliance With ARARs

Alternative 1 complies with most ARARs, but it does not meet all of the RAOs. A discussion of key ARARs is as follows:

1. Colorado Basic Standards and Methodologies and Site Specific Standards for Surface Water – This ARAR is met because surface water at the POCs meets surface water quality standards. However, surface water sample results do not always meet Colorado surface water quality standards for some analytes at some on-site monitoring locations upstream of the terminal ponds. Therefore, an institutional control will be needed to prevent use of surface water upstream of the terminal ponds.
2. Colorado Basic and Site Specific Standards for Groundwater – This ARAR is met because groundwater at the groundwater Area of Concern (AOC) wells and one or more Sentinel wells meets the groundwater quality standards. At Sentinel wells where groundwater data are above the groundwater quality standards, results of the RI conclude that, based on the environmental conditions and type of residual contamination, no additional action can reasonably be taken at this time. Groundwater and surface water monitoring will continue. In addition, contaminated groundwater has been addressed on a sitewide basis for three plume areas where groundwater treatment systems are installed and are performing as designed to improve groundwater quality that could adversely impact surface water quality. These systems will continue to be operated and monitored in accordance with their individual system monitoring and maintenance plans. Shallow (UHSU) groundwater impacted by site activities discharges to surface water upgradient of the site boundary. This impacted groundwater emanates from the former industrial area and discharges to surface water in the drainages upgradient of the terminal ponds. Water quality at AOC wells and Sentinel wells represent potential impacts from groundwater to surface water.

3. National Pollutant Discharge Elimination System (NPDES) – This ARAR is met because the existing NPDES permit, which covered stormwater discharges and sanitary sewage treatment plant discharges, has been properly terminated. Point source and stormwater sources covered by the permit have been removed as part of site closure. In addition, the discharge from the seep treatment system at the Present Landfill to surface water upstream of No Name Gulch meets NPDES substantive requirements for such discharges. As part of the accelerated action decision, the system discharge meets the CERCLA permit waiver provisions. The discharge will be monitored for VOCs and metals with effluent limitations that are the surface water quality standards for Walnut Creek, Big Dry Creek segment 4a.
4. Atomic Energy Act, Radiation Protection Standards for Decommissioning Licensed Facilities; Colorado Standards for Protection Against Radiation – These ARARs are met because residual levels of RFETS-related radiological soil contamination do not result in the exceedance of the 25 millirem (mrem) annual radiation dose limits for the WRW under the future RFETS land use as a wildlife refuge. If this land became unrestricted in the future, the annual dose limit for the unrestricted user would also not be exceeded (see Section 10.0).
5. Subtitle C: Hazardous Waste Management; Solid Waste Disposal Act; CHWA - Groundwater Protection and Monitoring – This ARAR is met because groundwater at the Present Landfill (including the landfill seep) and the Original Landfill will be monitored under 6 Code of Colorado Regulations (CCR) 1007-3, as required under the approved accelerated action decision documents.
6. Subtitle C: Hazardous Waste Management; Solid Waste Disposal Act; CHWA - Closure and Post Closure – This ARAR is met because the Present and Original Landfills were adequately stabilized and covers were properly installed in accordance with regulatory agency-approved designs and will be maintained and monitored in accordance with their individual landfill monitoring and maintenance plan under a post-closure care enforceable document to be determined by the RFCA Parties.
7. National Emission Standards for Asbestos – This ARAR is met at the Present Landfill because any asbestos-containing waste material was covered with at least 60 centimeters (cm) of compacted nonasbestos-containing material. The cover provides for ongoing containment of asbestos-containing waste material.
8. Environmental Covenants – This ARAR is met at the Present Landfill; however, the ARAR is not met for the remainder of the Central OU.

While Alternative 1 meets most ARARs, it does not meet all ARARs.

11.3.3.3 Long-Term Effectiveness and Permanence

Alternative 1 exhibits a moderate degree of long-term effectiveness and permanence for the reasons described below.

1. Most of the RFCA accelerated actions (except the landfills) included removal of contaminated structures and environmental media. Removal provides the highest level of long-term effectiveness and permanence; however, it is not technically feasible to remove all residual contamination. Soil disturbed during accelerated actions has been revegetated in accordance with the RFETS revegetation plan and temporary erosion controls have been implemented to reduce erosion while new vegetation is being established.
2. Where an accelerated action was not required for subsurface contamination, the contaminated structure or media is fixed and/or not considered mobile in the environment. Remaining building structures either meet free release standards or have fixed contamination that is 6 ft or more below ground surface. PRGs were based on exposure scenarios to subsurface contamination to 8 ft below the surface. However, excavations below 3 ft are not likely unless mechanical excavation equipment is employed. Thus, inadvertent contact with subsurface soil deeper than 3 ft is considered unlikely.
3. Residual plutonium-239/240 persists indefinitely (for the purposes of this analysis), with radioactive half-lives for plutonium-239 and plutonium-240 of approximately 24,390 and 6,537 years, respectively. The primary historic source of plutonium-239/240 in surface soil was remediated at the historical 903 Pad/Lip area through a RFCA accelerated action, which should improve long-term surface water quality. In addition, removal of impervious surfaces has decreased runoff volumes and peak discharge rates, which will reduce soil erosion with its associated plutonium-239/240 transport and impact on surface water and sediment.
4. Given published information and available data at RFETS, it is likely that residual VOC sources and associated downgradient groundwater concentrations will persist for decades to hundreds of years even with the source removals taken under accelerated actions. Although it is possible to reduce the long-term persistence of the source term with appropriate technology, it would be technically impracticable to attempt to locate and characterize each source and very localized impacted areas due to relatively small release volumes (many less than 100 gallons). Long-term fate and transport modeling showed that, assuming sources remain the way they are now, the impacts to surface water would be minimal due to the following: (1) many sources will not impact groundwater above surface water standards at discharge points, (2) where concentrations are above surface water standards, the total flux into streams is limited due to the ephemeral nature of baseflow and seep flow to streams, and (3) groundwater treatment systems and one-time enhancements have been implemented in these areas.
5. The Present Landfill closure, as approved by the regulatory agencies, includes a multilayered cover consisting of geosynthetic and natural materials that are permanent and provide long-term effectiveness. The geosynthetic layers of the cover are protected by native soil both under and on top of the geosynthetics, and the cover is further protected from burrowing animals by an additional rock layer above the

geosynthetics. The entire landfill area is then covered with 2 ft of vegetated native soil for additional protection of the cover layers below. The seep treatment system is made of concrete, fiberglass, and high-density polyethylene components to provide a permanent system with little maintenance.

6. The Original Landfill accelerated action, as approved by the regulatory agencies, consists of a native soil buttress and native soil cover to provide for permanent containment of the landfill wastes and debris.
7. The three groundwater treatment systems are constructed of materials that, with routine maintenance at the treatment cells, are expected to have a long working life.
8. Monitoring of RFETS groundwater and surface water will provide the environmental data to verify the long-term effectiveness and permanence of the accelerated actions taken at RFETS.

11.3.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 1 exhibits a high degree of reduction of toxicity, mobility, or volume for the following reasons:

1. The three groundwater treatment systems provide for a reduction of VOCs or uranium and nitrate, reducing the overall volume of contaminants in the groundwater and protecting the adjacent surface water.
2. The Present Landfill seep treatment system provides treatment to remove the VOC contamination from the landfill seep. Experience and knowledge gained during accelerated actions have shown that it is not technically feasible to reduce toxicity, mobility, or volume of residual plutonium in surface soil through treatment.

11.3.3.5 Short-Term Effectiveness

Alternative 1 exhibits a high degree of short-term effectiveness because workers and the public are not at risk because no additional action is required in this alternative.

11.3.3.6 Implementability

Alternative 1 is easily implemented because all of the accelerated actions are complete, post-accelerated action monitoring at the Present and Original Landfills has been established, and the IMP surface water and groundwater monitoring stations have also been established.

11.3.3.7 Cost

Capital expenditures for Alternative 1 are not required because all of the required systems were previously installed as part of the completed accelerated action. The O&M costs include the following:

1. Cost of cover inspection and maintenance at the Present Landfill and the Original Landfill;
2. Seep treatment system monitoring and maintenance at the Present Landfill;
3. Groundwater monitoring at the Present Landfill;
4. Groundwater and surface water monitoring at the Original Landfill;
5. Monitoring and maintenance of the three existing groundwater treatment systems;
6. Monitoring and maintenance of the IMP surface water and groundwater stations;
7. Groundwater treatment system media replacement every 5 years; and
8. Preparation of materials for the CERCLA periodic reviews.

The estimated total O&M costs for Items 1 through 6 are \$2,530,000 per year. Groundwater treatment system media replacement costs are estimated at \$728,000 every 5 years. The estimated costs for preparing materials for the CERCLA periodic reviews are \$153,000.

The present worth of these costs for 30 years at an annual interest rate of 5 percent is \$41,350,000.

Details of this cost estimate are included in Attachment 1.

11.3.3.8 State Acceptance

Discussion of this criterion will be provided in the CAD/ROD.

11.3.3.9 Community Acceptance

Discussion of this criterion will be provided in the CAD/ROD.

11.3.4 Alternative 2: Institutional and Physical Controls

The evaluation of this alternative includes the evaluation presented for Alternative 1 and the additional assessment of adding institutional and physical controls to Alternative 1.

11.3.4.1 Overall Protection of Human Health and the Environment

Implementation of Alternative 2 is protective of human health and the environment by providing the institutional controls described below for the Central OU.

1. The construction and use of buildings that will be occupied on a permanent or temporary basis (such as for residences, offices, shops, break rooms, and so forth) is prohibited. The construction and use of storage sheds or other nonoccupied structures

are permitted, consistent with the restrictions contained in Steps 2 and 3 below, and provided such use does not impair any aspect of the response action at Rocky Flats.

2. Excavation, drilling, and other intrusive activities below a depth of 3 ft is prohibited, except for remedy-related purposes.
3. No grading, excavation, digging, tilling, or other disturbance of any kind of surface soils is permitted, except in accordance with an erosion control plan approved by CDPHE or EPA. Any such soil disturbance shall restore the soil surface to pre-existing grade.
4. Surface water above the terminal ponds may not be used for drinking water or agricultural purposes.
5. The construction or operation of groundwater wells is prohibited, except for remedy-related purposes.
6. Digging, drilling, tilling, grading, excavation, construction of any sort (including construction of any structures, paths, trails, or roads), and vehicular traffic are prohibited on the covers of the Present Landfill and the Original Landfill, except for authorized response actions.
7. Activities that may damage or impair the proper functioning of any engineered component of the response action, including but not limited to any treatment system, monitoring well, landfill cap, or surveyed benchmark, are prohibited.

Signs will also be installed as a physical control along the perimeter of the Central OU to notify the WRW and WRV that they are at the boundary of the Refuge maintained by USFWS.

11.3.4.2 Compliance With ARARs

Alternative 2 meets all of the ARARs (Section 11.3.3.2). In addition, Alternative 2 meets all of the RAOs.

11.3.4.3 Long-Term Effectiveness and Permanence

Implementation of Alternative 2 will significantly increase the long-term effectiveness and permanence achieved by the accelerated actions because institutional controls are designed to provide the mechanisms that permanently maintain the completed actions conducted at RFETS.

In addition, an environmental covenant will be implemented that will increase the long-term permanence of institutional controls. This covenant will decrease the likelihood that institutional controls will fail in the very long term.

Physical controls (signage) will be constructed of materials that are highly durable.

11.3.4.4 *Reduction in Toxicity, Mobility, or Volume Through Treatment*

See Alternative 1 (Section 11.3.3.4).

11.3.4.5 *Short-Term Effectiveness*

Alternative 2 exhibits a high degree of short-term effectiveness because institutional controls are easily implemented and become effective immediately.

Workers and the public are not at risk associated with implementation of Alternative 2.

11.3.4.6 *Implementability*

Alternative 2 is easily implemented by a combination of administrative and physical controls, which are expected to include institutional controls, an environmental covenant, and limited construction work to install signage.

11.3.4.7 *Cost*

Capital expenditures for Alternative 2 are low and are associated with the preparation of specific written administrative controls and providing the personnel to implement and monitor compliance with the institutional control requirements. Deed restrictions must be prepared and filed and the installation of signage completed and maintained.

The estimated capital cost of Alternative 2 is \$1,120,000.

O&M costs associated with the institutional controls aspect of Alternative 2 are estimated at \$45,000 per year and include the quarterly inspection of the site and signage, and a nominal amount of legal support.

The total O&M costs include Alternative 1 and inspection and maintenance of institutional and physical controls.

The estimated total annual O&M costs for these items are \$2,575,000 per year less the media replacement costs and the CERCLA periodic review costs.

The total present worth of these estimated costs for 30 years at 5 percent annual interest is \$43,170,000.

Details of this cost estimate are included in Attachment 1.

11.3.4.8 *State Acceptance*

Discussion of this criterion will be provided in the CAD/ROD.

11.3.4.9 *Community Acceptance*

Discussion of this criterion will be provided in the CAD/ROD.

11.3.5 Alternative 3: Targeted Surface Soil Removal

Alternative 3 will remove areas of surface soil within an EU that have been identified to have plutonium-239/240 contamination above the WRW target risk-based concentration of 9.8 pCi/g. Note that this alternative may not completely remove all plutonium contamination within the 368 acres, but the residual risk based on the EU is expected to be well below 1×10^{-6} if Alternative 3 is implemented. This alternative also includes the implementation of Alternative 2.

11.3.5.1 Overall Protection of Human Health and the Environment

Alternative 3 increases the protectiveness of human health because targeted surface soil removal will reduce plutonium-239/240 contamination to below the WRW target risk-based concentration of 9.8 pCi/g.

However, implementing Alternative 3 would negatively impact the environment. The removal process would destroy the existing native vegetation within the excavation area. It would also destroy some areas that are designated as Preble's meadow jumping mouse (PMJM) habitat. During and after the removal operations, the potential for large sediment loads into the Walnut Creek and Woman Creek drainages would be high. Thus, to comply with ARARs, special attention must be paid to surface runoff and runoff controls. With the current extent of high-quality vegetation in this area, the contaminated area currently does not result in any surface water exceedances at the surface water POCs.

11.3.5.2 Compliance With ARARs

Alternative 3 meets all of the ARARs (Section 11.3.3.2). The disturbance of surface soil could temporarily increase the sediment loading in surface water. However, it is anticipated that surface water standards would continue to be met at the surface water POCs. Any potential air impacts will be mitigated during implementation of the remedy.

11.3.5.3 Long-Term Effectiveness and Permanence

Implementing this alternative increases the overall long-term effectiveness and permanence for the following reasons:

1. Removal of surface soil will permanently and effectively reduce residual plutonium-239/240 contamination to below the WRW target risk-based concentration of 9.8 pCi/g.
2. Surface soil removal reduces remaining residual surface contamination that could be mobilized in the future if disturbed.

However, vegetation destroyed by the removal action could require up to 5 years to recover.

11.3.5.4 Reduction in Toxicity, Mobility, or Volume Through Treatment

See Alternative 1 (Section 11.3.3.4).

11.3.5.5 Short-Term Effectiveness

Alternative 3 has low short-term effectiveness because:

1. Removal of surface soil in Alternative 3 will result in an incremental risk to the workers and the public through the removal and transportation operations.
2. Removal of surface soil will result in significant short-term adverse impacts to ecological resources.
3. Removal of surface soil increases the potential to mobilize residual contamination, particularly if a large area of soil is removed, or if the removal is on a steep slope or in close proximity to a stream segment. It also increases the potential for wind erosion.

11.3.5.6 Implementability

This alternative is moderately difficult to implement. Even though standard earthmoving and transportation equipment is readily available, implementing the alternative without impacting surface water quality is difficult. Weather, wind, and precipitation will increase the potential for soil erosion and sediment loads to the RFETS drainages. Major construction to support the long duration of the work (new temporary roadways and possibly a new temporary railroad spur) would be required to implement Alternative 3. Implementation of a LLW disposal program compliant with DOE, U.S. Department of Transportation (DOT), and disposal facility waste acceptance criteria is moderate to difficult.

11.3.5.7 Cost

Capital expenditures for Alternative 3 include the cost for the removal and disposal of the soil and the repair of the disturbed area (revegetation and erosion control).

The estimated capital cost of Alternative 3 is \$222,340,000.

The O&M costs for Alternative 3 include the cost of inspection and maintenance of the area where surface soil was removed and the area revegetated. The O&M cost is estimated to vary over the first 5 years until the revegetation has been established. The O&M costs are estimated to vary from \$206,000 (Year 1) to \$70,000 (per year, starting at Year 5 through Year 30).

The estimated total capital cost, including Alternative 2 costs, is \$223,460,000.

The estimated total annual O&M cost, including Alternative 2 costs, ranges from \$2,781,000 to \$2,645,000 per year less the media replacement costs and CERCLA periodic review costs.

The present worth of these estimated costs for 30 years is \$265,510,000, including Alternative 2.

Details of this cost estimate are included in Attachment 1.

11.3.5.8 State Acceptance

Discussion of this criterion will be provided in the CAD/ROD.

11.3.5.9 Community Acceptance

Discussion of this criterion will be provided in the CAD/ROD.

11.4 Comparative Analysis of Alternatives

The following sections present the comparison between the alternatives considered.

11.4.1 Overall Protection of Human Health and the Environment

Alternative 1 is protective of human health and the environment in the current site land configuration because no unacceptable risks from residual contamination exist after the completion of all planned RFCA accelerated actions. However, Alternative 1 is not the most protective of human health and the environment for the reasons described below.

1. Because the CRA does not evaluate an unrestricted scenario, but instead evaluates potential risk to the anticipated future user (WRW and WRV), the assumptions used in the CRA human health calculations, including the assumptions used in calculating WRW PRGs, need to be embodied in an institutional control. The detailed analysis of alternatives evaluated alternatives that include the underlying assumptions used in the CRA human health calculations as an institutional control.
2. Residual soil contamination exists in the Central OU. If residual soil contamination is disturbed, the residual contamination could migrate to surface water via erosion which could result in some surface water sample results above surface water standards at some surface water monitoring locations. Alternative 1 does not prevent the disturbance of soil.
3. Contaminated subsurface features remain in the subsurface (Section 2.0) in the former IA. These features were not evaluated in the CRA because they are not an environmental medium and because of the exposure assumption in the CRA that there is no exposure pathway for a WRW because he or she will not be digging below 3 ft. Consequently, this CRA assumption needs to be embodied in an institutional control.

4. Subsurface soil and groundwater contamination exists above the indoor air volatilization PRGs. Alternative 1 does not actively prevent the possibility of an unacceptable risk of exposure to the WRW if a building were constructed over the area contaminated above the indoor air volatilization PRGs and the building was routinely occupied.
5. Groundwater contamination exists in the Central OU above MCLs. Alternative 1 does not actively prevent the use of this groundwater for drinking water or irrigation purposes. However, reliable sources of on-site groundwater for use as drinking water or irrigation are doubtful based on extensive hydrogeologic studies.
6. Surface water quality standards are met at the surface water POCs. However, surface water sample results do not always meet Colorado surface water standards for some analytes at some on-site surface water monitoring locations upstream of the terminal ponds. Alternative 1 does not actively prevent the use of this surface water.
7. The Present Landfill RFCA decision document requires institutional controls to be put in place at the time the post-closure period begins. However, institutional controls for the Original Landfill are not in place.
8. There are no prohibitions on the engineered aspects of the remedy.

Alternatives 2 and 3 provide overall protection to human health and the environment. However, Alternative 3 further reduces risk to a WRW by removing areas of residual plutonium-239/240 surface soil contamination, but the short-term impact to the environment and cost of additional surface soil removal above the target risk-based concentration of 9.8 pCi/g is high.

11.4.2 Compliance With ARARs

Alternatives 2 and 3 meet the ARARs for RFETS through institutional controls.

11.4.3 Long-Term Effectiveness and Permanence

With the completion of all RFETS actions, Alternative 1 achieves a moderate degree of long-term effectiveness and permanence. The accelerated action closures of the Present Landfill and Original Landfill, and the operation of three groundwater treatment systems, are designed for long-term physical integrity and use. Monitoring and maintenance plans are implemented to sustain the effectiveness and permanence of these actions. However, long-term effectiveness and permanence for Alternative 1 is compromised by the absence of institutional controls. Alternative 2 increases the effectiveness and permanence of the actions by reducing exposures resulting in acceptable risk to the WRW through institutional controls that prohibit the construction and use of buildings and by placing restrictions on excavation or activities that cause soil disturbance. Institutional controls will prevent the use of surface water, and groundwater and/or pumping groundwater where the remedy may be impacted in the Central OU. Alternative 3 removes surface soil with residual contamination of plutonium-239/240 above the target risk-based

concentration of 9.8 pCi/g and provides, through removal, a permanent and effective action.

In conclusion for this criterion, Alternative 3 provides the most permanent long-term action. Alternative 2 is ranked second only to Alternative 3 in long-term effectiveness.

11.4.4 Reduction in Toxicity, Mobility, or Volume Through Treatment

All of the alternatives are equivalent because the only treatment considered in any of the alternatives occurs in the groundwater and Present Landfill seep treatment systems, which remain the same through all of the alternatives.

11.4.5 Short-Term Effectiveness

Alternatives 1 and 2 provide a high degree of short-term effectiveness because the alternatives will not pose a risk to the workers or the public during implementation. The removal of large areas of surface soil with residual contamination as described in Alternative 3 will entail increased risks to workers from earthmoving and waste transportation activities. Risks to the public are expected to be low, although higher than from Alternatives 1 and 2. This risk is due to the large volume of soil and waste materials to be excavated and transported off site for disposal. Additionally, there will be a short-term impact to affected ecological resources that increases with the amount of sediment loading to surface water.

In conclusion for this criterion, Alternatives 1 and 2 provide the most short-term effectiveness.

11.4.6 Implementability

Alternative 1 is easily implemented because no further removal actions need to be conducted. In addition, the IMP and landfills and groundwater treatment monitoring systems are already in place.

Alternative 2 is easily implemented by initiating deed restrictions and limited construction work to install the physical controls (signage). These activities are not expected to entail direct exposure to residual contamination.

Alternative 3 is moderately difficult to implement. Even though standard earthmoving and transportation equipment is readily available, implementing the alternative without impacting surface water quality is difficult. The implementation of the surface soil removal is difficult due to the large extent and large volume of soil to be managed. Wind and precipitation will also increase the potential for soil erosion and sediment loads to the RFETS drainages during the removal process. Major construction to support the long duration of the work (for example, new temporary roadways) would be required to implement Alternative 3.

In conclusion for this criterion, Alternative 1 is the most implementable alternative.

11.4.7 Cost

The cost of Alternative 1 is only slightly increased by the addition of Alternative 2 (5 percent increase in present worth cost). The removal of surface soil contamination in Alternative 3 adds a large increment of cost (750 percent increase in present worth cost). Alternative 3 provides only a small incremental benefit (reducing potential risk from 2×10^{-6} to below 1×10^{-6}) and entails high costs and high short-term risks (increased worker risk and mobilization of contaminants).

In conclusion for this criterion, Alternative 2 is the most cost-effective action.

11.4.8 State Acceptance

Discussion of this criterion will be provided in the CAD/ROD.

11.4.9 Community Acceptance

Discussion of this criterion will be provided in the CAD/ROD.

11.5 References

K-H, 2005, Integrated Monitoring Plan FY05, Summary and Background Document, Revision 1, Rocky Flats Environmental Technology Site, Golden, Colorado, September.

OMB, 2005, Office of Management and Budget Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, Appendix C, January.

TABLES

Table 11.1
Analysis of Alternatives for the Proposed Central OU

	No Further Action With Monitoring (Alternative 1)	Institutional and Physical Controls (Alternative 2)	Targeted Surface Soil Removal (Alternative 3)
Alternative Description	Maintains and monitors the completed actions conducted at the Present and Original Landfills and the three groundwater treatment systems. Specific monitoring and O&M requirements for these five actions will continue. Alternative 1 also includes additional surface water, sediment, and ecological monitoring based on results of the ERA and surface and groundwater monitoring as described in the FY2005 IMP, dated September 8, 2005.	Includes Alternative 1 plus institutional and physical controls. Institutional controls include legally enforceable and administrative land use restrictions. Physical controls include signs.	Includes Alternative 2 plus targeted removal of surface soil within an EU to reduce the residual plutonium-239/240 contamination to below 9.8 pCi/g, which is the 1×10^{-6} WRW target risk concentration.
Evaluation Criteria			
Protection of Human Health and the Environment	<p>This alternative is protective of human health and the environment in the current site land configuration because no unacceptable risks from residual contamination exist after completion of all planned accelerated actions.</p> <ul style="list-style-type: none">• The CRA shows that the incremental risk to the WRW falls within the acceptable range of 1×10^{-6} to 1×10^{-4} cancer risks and below an HI of 1 for noncarcinogenic effects.• The CRA predicts that there is no significant ecological risk from residual contamination within all environmental media across RFETS.• Actions at the Present and Original Landfills provide protection of human health and the environment.• Groundwater actions are operating as designed to remove contamination captured to meet appropriate surface water quality standards at surface water POCs.• Monitoring of groundwater, surface water, sediment, and ecology provides data to verify that RFETS continues to be protective of human health and the environment. The IMP also includes environmental monitoring of the Present and Original Landfills, the Present Landfill seep treatment system, and the three groundwater treatment systems. <p>This alternative may not be protective of human health if the current site land configuration were to change. In particular:</p> <ul style="list-style-type: none">• Because the CRA does not evaluate an unrestricted scenario, but instead evaluates potential risk to the anticipated future user, the assumptions used in the CRA human health calculations, including the assumptions used in calculating the WRW PRGs, need to be embodied in an institutional control.• Residual soil contamination exists in the Central OU. If residual soil contamination is disturbed, the contamination could migrate to surface water via erosion which could result in some surface water sample results above surface water standards at some surface water monitoring locations.• Subsurface soil and groundwater contamination exists above the indoor air volatilization PRGs.• Groundwater contamination exists in the Central OU above MCLs.• Surface water quality standards are met at the surface water POCs. However, surface water sample results do not always meet Colorado surface water standards for some analytes at some on-site surface water monitoring locations upstream of the terminal ponds.• Institutional controls for the Original Landfill are not in place.• There are no prohibitions on affecting the engineered aspects of the remedy.	<p>This alternative is protective of human health and the environment because:</p> <ul style="list-style-type: none">• See Alternative 1.• Alternative 2 increases the protectiveness of Alternative 1 because institutional controls will provide the following:<ul style="list-style-type: none">- The construction and use of buildings that will be occupied on a permanent or temporary basis (such as for residences, offices, shops, break rooms, and so forth) is prohibited. The construction and use of storage sheds or other nonoccupied structures is permitted, consistent with the restrictions below, and provided such use does not impair any aspect of the response action at Rocky Flats.- Excavation, drilling, and other intrusive activities below a depth of 3 ft are prohibited, except for remedy-related purposes.- No grading, excavation, digging, tilling, or other disturbance of any kind of surface soils is permitted, except in accordance with an erosion control plan approved by CDPHE or EPA. Any such soil disturbance shall restore the soil surface to pre-existing grade.- Surface water above the terminal ponds may not be used for drinking water or agricultural purposes.- The construction or operation of groundwater wells is prohibited, except for remedy-related purposes.- Digging, drilling, tilling, grading, excavation, construction of any sort (including construction of any structures, paths, trails, or roads), and vehicular traffic are prohibited on the covers of the Present Landfill and the Original Landfill, except for authorized response actions.- Activities that may damage or impair the proper functioning of any engineered component of the response action, including but not limited to any treatment system, monitoring well, landfill cap, or surveyed benchmark, are prohibited.- Signs will be installed as a physical control along the perimeter of the Central OU to notify the WRW and WRV that they are at the boundary of the Refuge maintained by USFWS.	<p>This alternative is protective of human health and the environment because:</p> <ul style="list-style-type: none">• See Alternatives 1 and 2.• Alternative 3 increases the protectiveness of Alternatives 1 and 2 because targeted surface soil removal will reduce plutonium-239/240 contamination to below 9.8 pCi/g.• Surface soil removal will result in short-term adverse impacts to ecological resources, including potential impacts to PMJM habitat.• Removal of surface soil increases the potential to mobilize residual contamination, particularly if a large area of soil is removed, or if the removal is on a steep slope or in close proximity to a stream segment. It also increases the potential for wind erosion.

Table 11.1
Analysis of Alternatives for the Proposed Central OU

	No Further Action With Monitoring (Alternative 1)		Institutional and Physical Controls (Alternative 2)		Targeted Surface Soil Removal (Alternative 3)
Compliance With ARARs and RAOs	This alternative complies with most ARARs; however, it does not meet all ARARs. This alternative does not meet all RAOs.		This alternative complies with all ARARs and meets all RAOs.		This alternative complies with all ARARs and meets all RAOs.
Long-Term Effectiveness and Permanence	<ul style="list-style-type: none"> Most of the RFCA accelerated actions (except the landfills) included removal of contaminated structures and environmental media providing a high degree of long-term effectiveness and permanence. Landfills have been closed in accordance with regulatory agency-approved closure plans as long-term solutions. Remaining building structures either meet free release standards or have fixed contamination that is 6 ft or more below ground surface. Groundwater treatment systems are permanent passive systems requiring limited operational attention. Monitoring of groundwater and surface water provides additional assurance of permanence. 		See Alternative 1 plus: <ul style="list-style-type: none"> Institutional controls are designed to provide the mechanisms that permanently maintain the completed actions conducted at RFETS and the monitoring consistent with the requirements in all accelerated action decision documents. In the very long term, institutional controls may fail. An environmental covenant will increase the long-term permanence of institutional controls. 		See Alternative 2 plus: <ul style="list-style-type: none"> Removal of surface soil will permanently and effectively reduce plutonium-239/240 contamination to below 9.8 pCi/g. Surface soil removal reduces remaining residual surface contamination that could be mobilized in the future if disturbed.
Reduction of Toxicity, Mobility, or Volume Through Treatment	<ul style="list-style-type: none"> Groundwater treatment systems provide for a reduction of VOCs or uranium and nitrate reducing the overall volume of contaminants in the groundwater and protecting the adjacent surface water. The Present Landfill seep treatment system provides treatment to remove the VOC contamination from the landfill seep. 		See Alternative 1.		See Alternative 1.
Short-Term Effectiveness	Workers and the public are not at risk because no additional action is required in this alternative.		See Alternative 1 plus: <ul style="list-style-type: none"> Institutional controls are effective immediately after the controls have been established. 		See Alternative 2 plus: <ul style="list-style-type: none"> Removal of surface soil will result in an incremental risk to the workers and the public through the removal and transportation operations. Surface soil removal will result in short-term adverse impacts to ecological resources. Removal of surface soil increases the potential to mobilize residual contamination, particularly if a large area of soil is removed, or if the removal is on a steep slope or in close proximity to a stream segment. It also increases the potential for wind erosion.
Implementability	<ul style="list-style-type: none"> No further action is easily implemented because all accelerated actions are complete. Post-accelerated action monitoring of the Present and Original Landfills is easily implemented because the monitoring systems are established. Monitoring through the IMP is easily implemented because the monitoring network is established. 		See Alternative 1 plus: <ul style="list-style-type: none"> Institutional controls and an environmental covenant are easily implemented. Physical controls, such as signage, are easily implemented. 		See Alternative 2 plus: <ul style="list-style-type: none"> Even though standard earthmoving and transportation equipment is readily available, implementing the alternative without impacting surface water quality is difficult. Weather, wind, and precipitation will increase the potential for soil erosion and sediment loads to the RFETS drainages. Major construction to support the long duration of the work would be required.

Table 11.1
Analysis of Alternatives for the Proposed Central OU

	No Further Action With Monitoring (Alternative 1)		Institutional and Physical Controls (Alternative 2)		Targeted Surface Soil Removal (Alternative 3)
Cost ^a	Capital Cost: \$0 Annual O&M Cost: \$2,530,000 Present Worth Cost: \$41,350,000 Groundwater treatment system media replacement costs are estimated at \$728,000 every 5 years. The estimated costs for preparing materials for the CERCLA periodic reviews is \$153,000 every 5 years.		Capital Cost: \$1,120,000 Annual O&M Cost: \$45,000 (Alternative 2 only) Total Annual O&M Cost: \$2,575,000 (includes Alternatives 1 and 2), less the periodic media replacement costs and CERCLA review costs Present Worth Cost: \$43,170,000 (includes Alternatives 1 and 2)		Capital Cost: \$222,340,000 (assumes up to approximately 368 acres for surface soil removal and disposal as low-level radionuclide-contaminated soil) Total Capital Cost: \$223,460,000 (includes Alternatives 1, 2, and 3) Annual O&M Cost: Varies from \$206,000 to \$70,000 (Alternative 3 only) Total Annual O&M Cost: \$2,781,000 to \$2,645,000 (includes Alternatives 1, 2, and 3), less the periodic media replacement costs and CERCLA review costs Present Worth Cost: \$265,510,000 (includes Alternatives 1, 2, and 3)
State Acceptance	Discussion of this criterion will be provided in the CAD/ROD.		Discussion of this criterion will be provided in the CAD/ROD.		Discussion of this criterion will be provided in the CAD/ROD.
Community Acceptance	Discussion of this criterion will be provided in the CAD/ROD.		Discussion of this criterion will be provided in the CAD/ROD.		Discussion of this criterion will be provided in the CAD/ROD.

^a Capital costs are in 2005 dollars and O&M costs are calculated for 30 years at a discount rate of 5 percent.

FIGURES

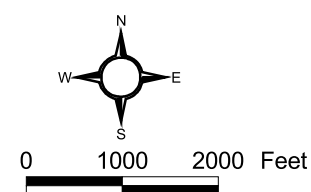
Figure 11.1
UHSU Groundwater Monitoring
Locations Where Composite
MCLs Were Exceeded

KEY

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- △ Sample collected between June 28, 1991 and December 31, 1994
- Concentrations > MCL
- Concentrations <= MCL

Standard Map Features

- Proposed Central OU boundary
- Pond
- Perennial stream
- Intermittent stream
- Ephemeral stream
- Site boundary



Scale 1:24,000
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental
Technology Site

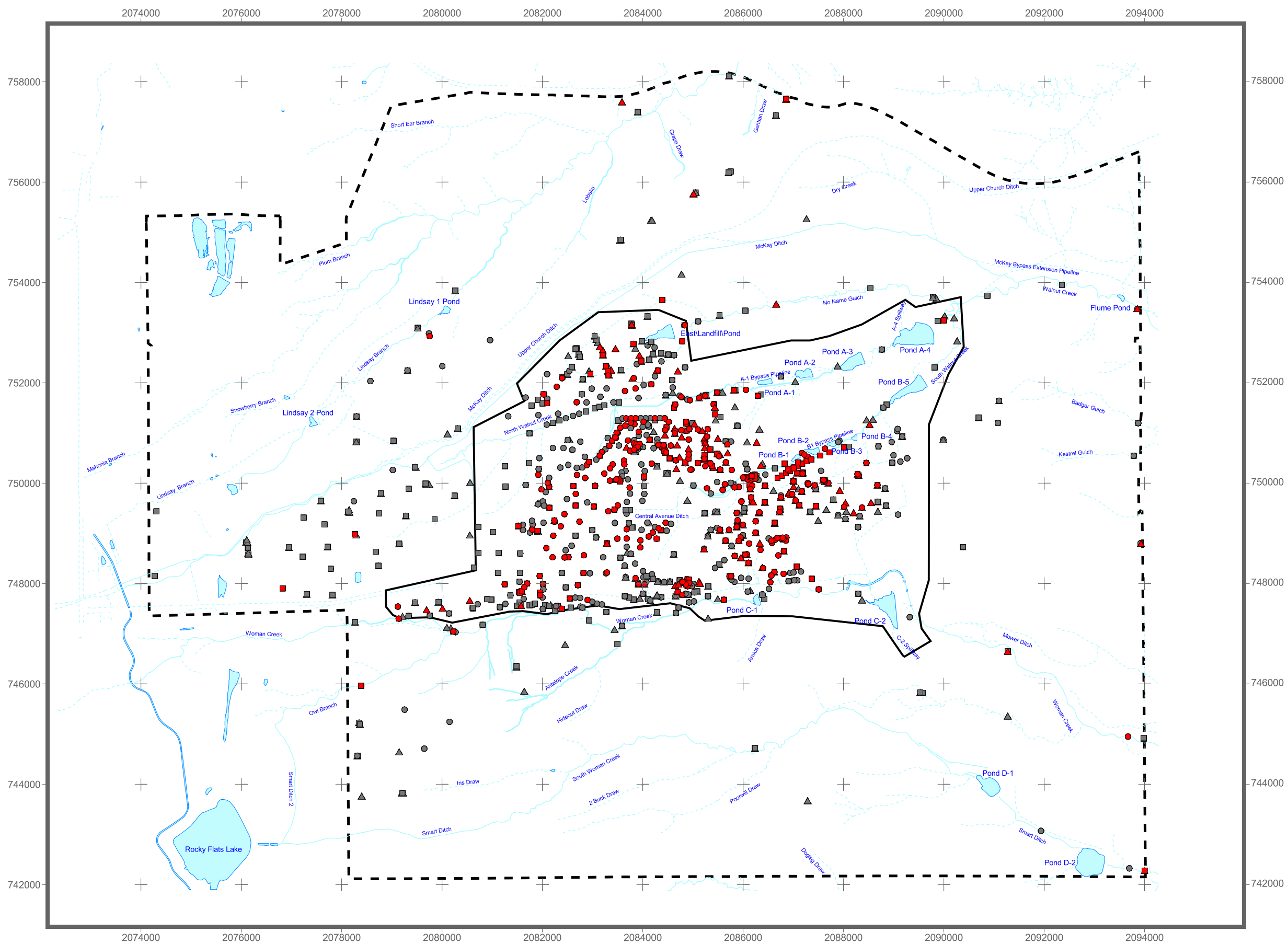
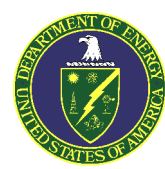


Figure 11.2

Subsurface Soil Sampling
Locations Where Volatilization
PRGs Were Exceeded

KEY

- Exceeded volatilization PRGs
- Did not exceed volatilization PRGs

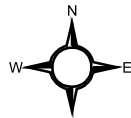
A location is classified as a PRG exceedance if any analyte was detected at a concentration exceeding its PRG since June 28, 1991.

Standard Map Features

- Proposed Central OU boundary
- Historical IHSS/PAC
- Site boundary
- Pond
- Perennial stream
- Intermittent stream
- Ephemeral stream

Exposure Units

- Industrial Area
- Inter-Drainage
- Lower Walnut Drainage
- Lower Woman Drainage
- No Name Gulch Drainage
- Rock Creek Drainage
- Southeast Buffer Zone Area
- Southwest Buffer Zone Area
- Upper Walnut Drainage
- Upper Woman Drainage
- West Area
- Wind Blown Area



0 1000 2000 Feet

Scale 1:24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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Figure 11.3
Groundwater Sampling Locations
Where Volatilization PRGs
Were Exceeded

KEY

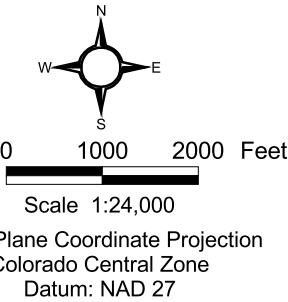
- Exceeded volatilization PRGs
 - Did not exceed volatilization PRGs
- A location is classified as a PRG exceedance if any analyte was detected at a concentration exceeding its PRG since June 28, 1991.

Standard Map Features

- Proposed Central OU boundary
- Historical IHSS/PAC
- Site boundary
- Pond
- Perennial stream
- Intermittent stream
- Ephemeral stream

Exposure Units

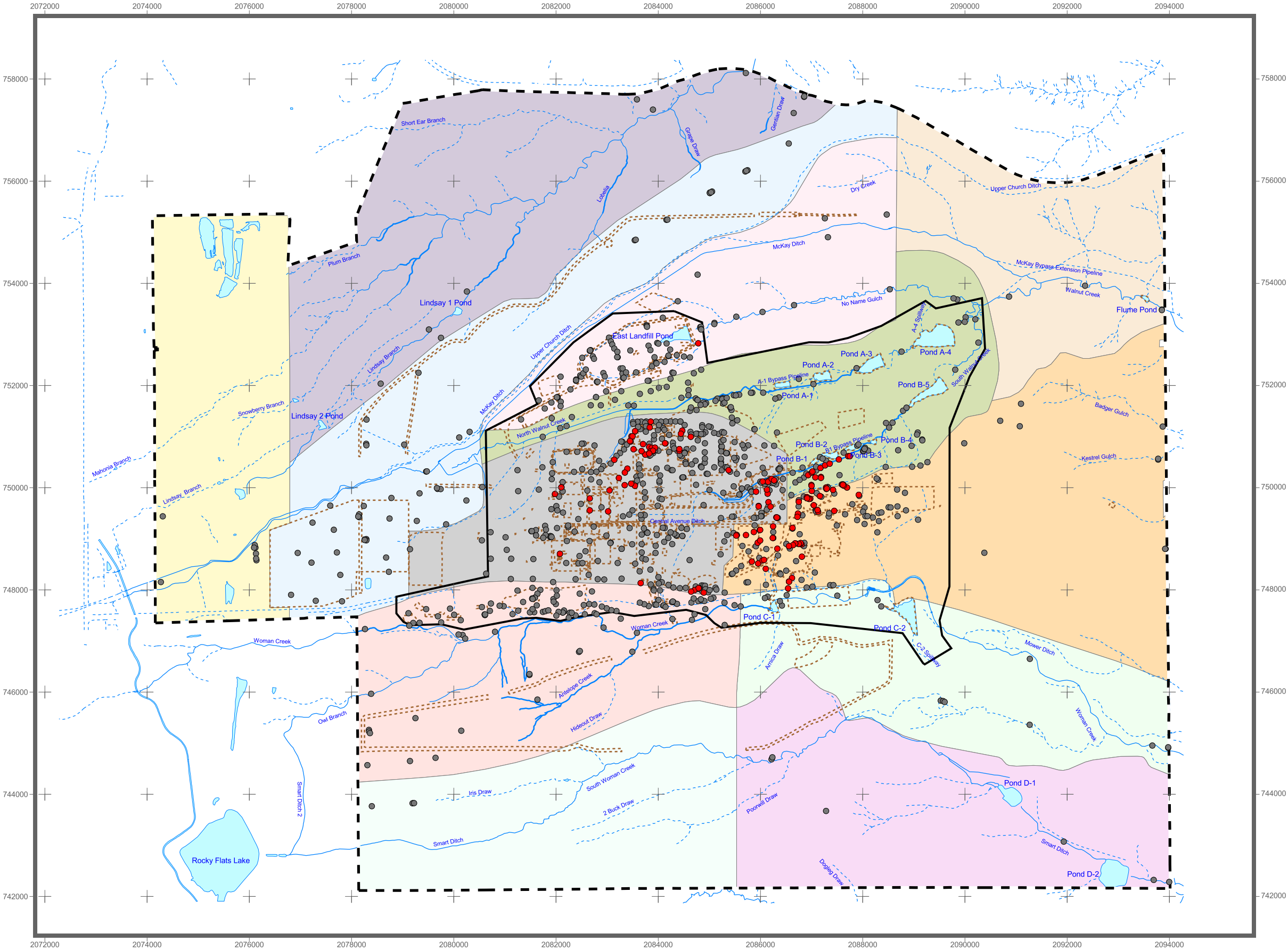
- Industrial Area
- Inter-Drainage
- Lower Walnut Drainage
- Lower Woman Drainage
- No Name Gulch Drainage
- Rock Creek Drainage
- Southeast Buffer Zone Area
- Southwest Buffer Zone Area
- Upper Walnut Drainage
- Upper Woman Drainage
- West Area
- Wind Blown Area

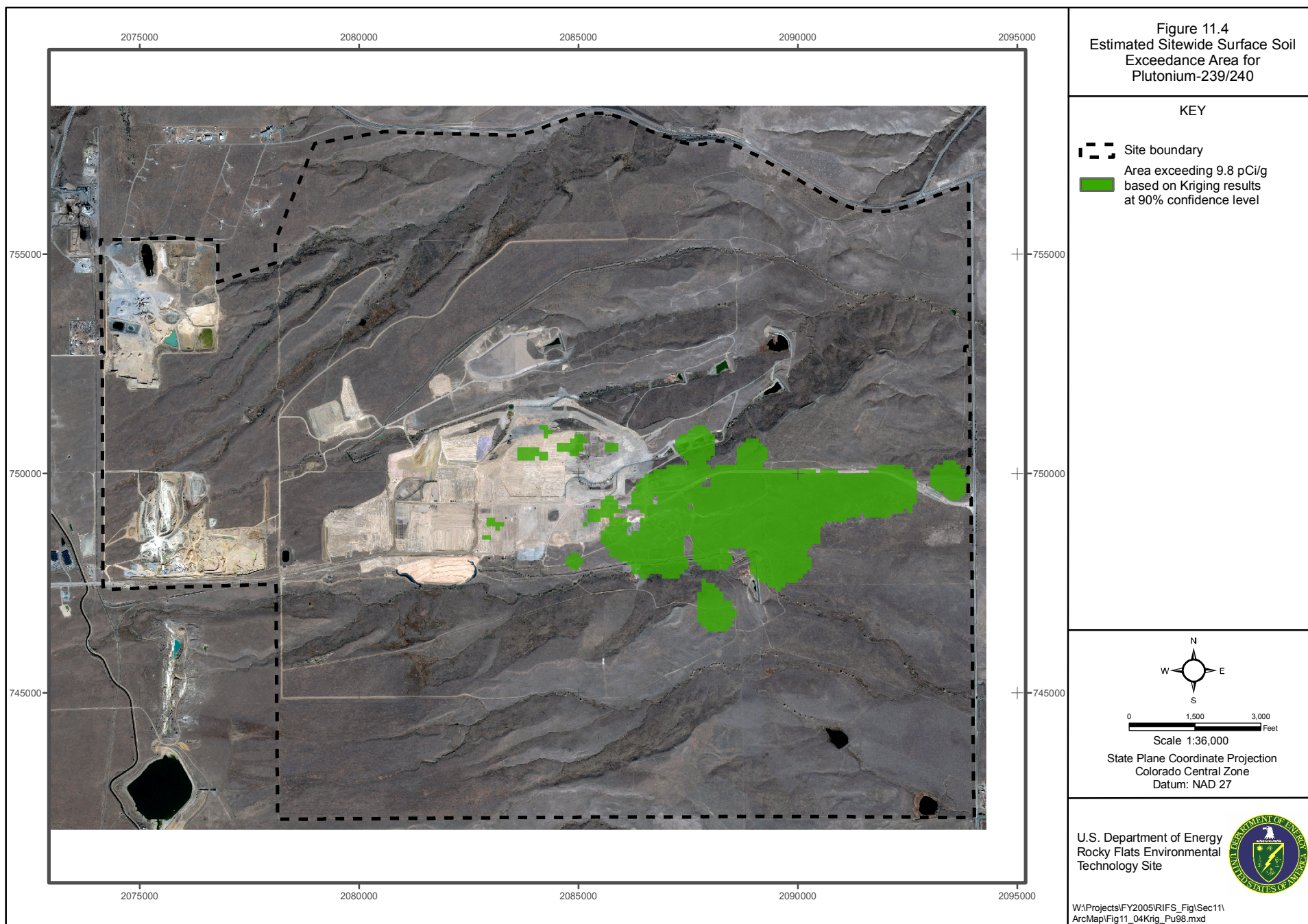


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**RCRA FACILITY INVESTIGATION – REMEDIAL INVESTIGATION/
CORRECTIVE MEASURES STUDY – FEASIBILITY STUDY REPORT**

DETAILED ANALYSIS OF ALTERNATIVES

SECTION 11.0: ATTACHMENT 1

CD ROM, Estimates of Costs

June 2006